AMERICAN JOURNAL OF SOCIAL SCIENCE
ISSN: 2996-5306 (online) | ResearchBib (IF) = 10.67 IMPACT FACTOR
Volume-3| Issue-7| 2025 Published: |30-07-2025|

THEORETICAL STUDY OF THE COTTON PURIFICATION SYSTEM FROM SMALL COMPOSITIONS AND DUST

https://doi.org/10.5281/zenodo.19897278

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Abstract. Research into the sources of small impurities and dust emissions from the technological process of the cotton ginning enterprise, the current state of cotton transportation equipment, and the processes of cleaning cotton from small impurities is a pressing problem.

The article examined the insufficient efficiency of existing cotton transportation and cleaning equipment and the possibility of optimizing cotton transportation and cleaning processes. Based on the analysis of scientific research on improving the process of cotton transportation and cleaning from trash and dust, it has been established that there are unresolved issues of theoretical and practical significance, in particular, when improving devices for cleaning cotton from small trash and dust, it is necessary to pay attention to energy and resource saving issues.

For this purpose, the system for cleaning cotton from small trash and dust has been improved. In this system, results were obtained based on the theoretical study of the movement of fine trash, fibrous waste, and dusty air.

Keywords: cotton, small trash, peg screw, dust, cleaning, device, steam generator, fan.

Introduction. Based on the improvement of the cotton transportation device, the possibility of increasing the efficiency of cleaning cotton from small trash and dust was revealed. The expediency of optimizing the processes of cotton transportation and cleaning has been established, and the need for theoretical research of these processes has been shown[1].

It is known that pneumatic and mechanical means are used for cotton transportation in cotton ginning plants [2].

During the processes of transportation and drying in the pneumatic transport system of cotton ginning enterprises, small impurities and dust are separated from the cotton and transferred with air to the portion of the void in the cotton. As a result, due to the transition of fine impurities and dust in cotton from a passive to an active state, they negatively affect the environment, transmission elements of technological equipment, and cotton products [3,4].

Therefore, it is effective to transfer cotton from the drying drum to the conveying device through an inclined chute and clean it on a spiked screw conveyor.

The advantages of screw conveyors are simplicity of construction and ease of maintenance, relatively small overall dimensions, ease of unloading the span, tightness, etc. [5,6].

In screw conveyors, the working part of the load conveyor is a screw installed so that it rotates inside a closed shell. The material moves along the shell with sliding and is removed from one or more places on it. In this case, the wadding moves along the working surface of the rotating screw and the shell located inside the shell. As a result, small impurities and dust in the cotton are separated in the transport and cleaning device [7].

The possibility of reducing the emission of small impurities and dust into the atmosphere with the air, separated in the device for transporting and cleaning cotton, was revealed. As a result of the conducted research, UZ FAP 2481 was obtained as a utility model for the "Device for cleaning drying agent (air) used in cotton dryers," which allows cleaning dust, fibrous waste, and trash impurities in the device for cleaning the drying agent (air) used in cotton dryers [8]. Water vapor and air used in the cotton dryer are supplied to the device. In it, a mixture of pollutants and dust from the exhaust air with water vapor is formed. As a result, due to an increase in the mass of dirt and dust and a decrease in the speed in the device, it separates from the air flow and is removed from the device through a vacuum valve. The purified air is sent to the next stage.

Based on this, an improved technological system consisting of a "Cotton Transportation and Cleaning Device - Pneumatic Transport - Dust Collector" was developed, which ensures high efficiency of cotton transportation and cleaning (Fig. 1).

Cotton is fed into the device through an inclined chute 1. In it, cotton is transported by a spiked screw 3 on the surface of the mesh surface 4, cleaned of impurities, and removed from the device through the outlet 5. The waste and dust separated in the device are sucked into the fan 9 through the waste hopper 6 and 7 and pipes 8. Water vapor generated in the steam generator 11 is injected into the dust and fibrous waste collection bunker via pipe 13 from the fan 10 using a sprayer 12. Fine trash and fibrous waste are mixed with water vapor and fed into bunker 13. In the hopper, a mixture of trash, dust, and fibrous waste, as well as water vapor, is formed, and due to an increase in their mass, a large volume of the chamber, and vertical barrier elements in it, the speed of the drying agent decreases, and trash and fibrous waste are removed from the device through a vacuum valve. In the device, air purified from small impurities and dust is sent to the next process through a pipeline.

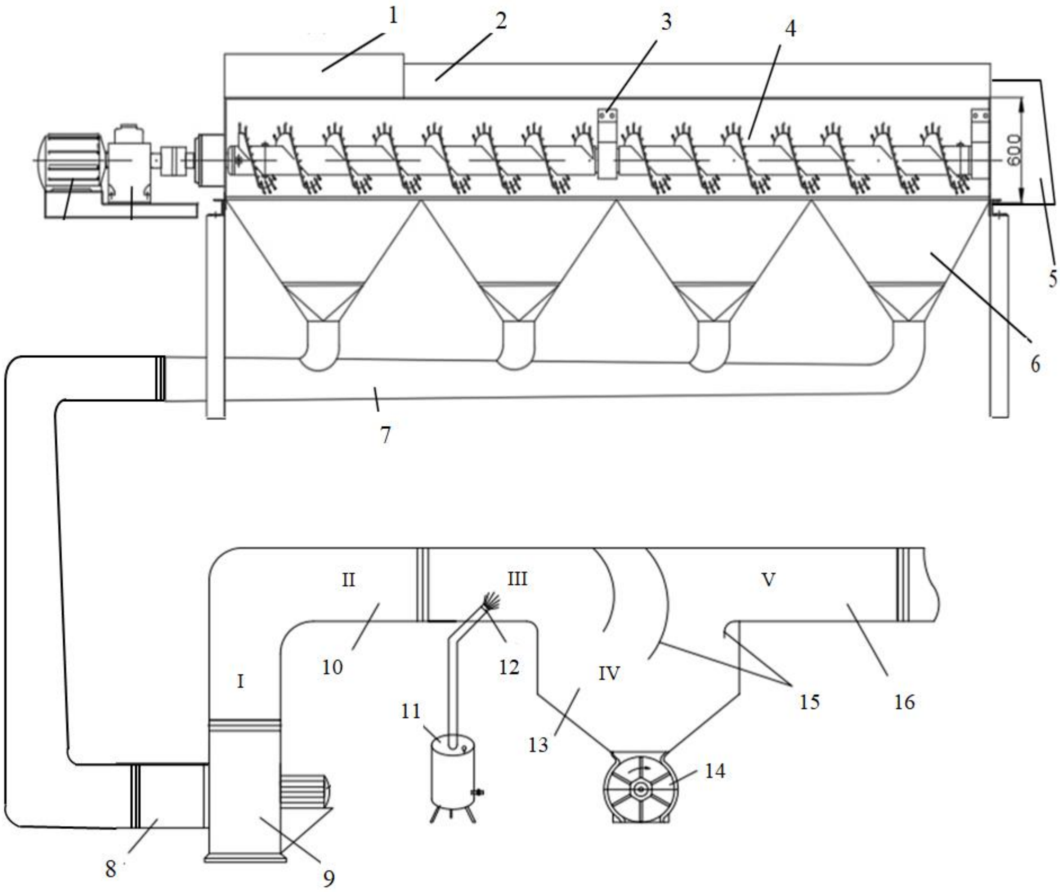

Fig. 1. Diagram of an improved system for cleaning cotton and used dusty air.

1 - inclined drain; 2 - spiked screw; 3 - bracket; 4-grid surface; 5-exit part of cleaned cotton; 6-contamination hopper; 7 - pipe for collecting trash and dust; 8-suction pipe to the fan; 9 - fan; 10 - supply pipe to the dust air purification device; 11-steam generator; 12 - steam sprayer; 13-bunker for collecting dust and fibrous waste; 14-vacuum valve; 15 - vertical barrier elements and 16 - purified air duct.

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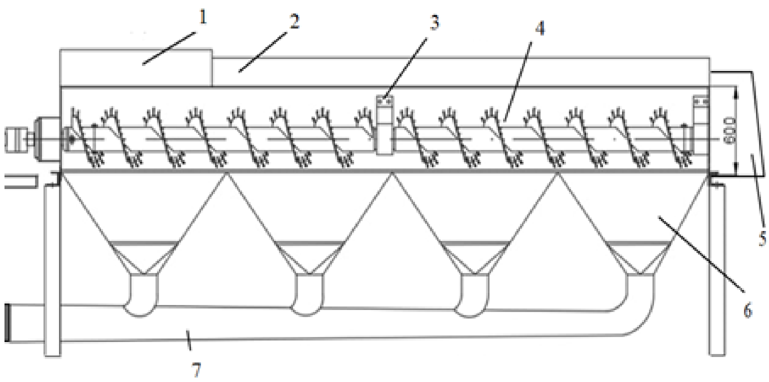

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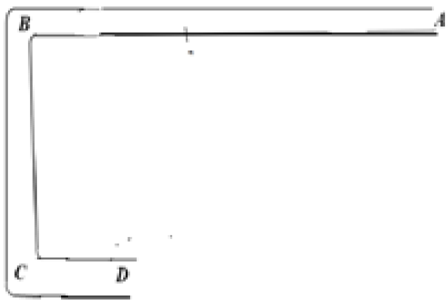

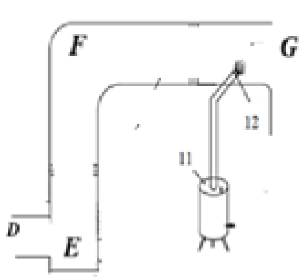

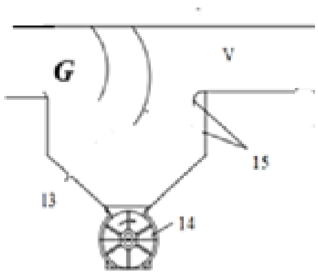

2) 3) 4)

Fig. 2. Diagram of a device for cleaning cotton and dusty air divided into zones (transitions).

1-zone for separating small trash and dust; 2-mixture transfer zone; 3-mixture preparation zone; 4 - zone of separation from air from fibers and trash.

1. The process of cotton transportation, cleaning from small trash and dust in the zone of separation of small trash and dust from cotton [9] was studied. It conducted research on improving the ecological situation, improving the technology of cotton processing and its scientific foundations.

In this direction, in order to save energy and resources, a device for transporting cotton, separating small trash and dust, with integrated technological processes, has been developed. The scientific basis of its parameters and operating modes has been studied[10]. The results of practical and theoretical studies of the processes of separating impurities from raw cotton are described in detail in the works.

For this purpose, the SHX type cotton conveyor for cleaning trash and dust at the initial stage of cotton processing has been improved. Theoretical studies were conducted on the study of the speed of cotton flow in an improved device for cotton transportation and cleaning.

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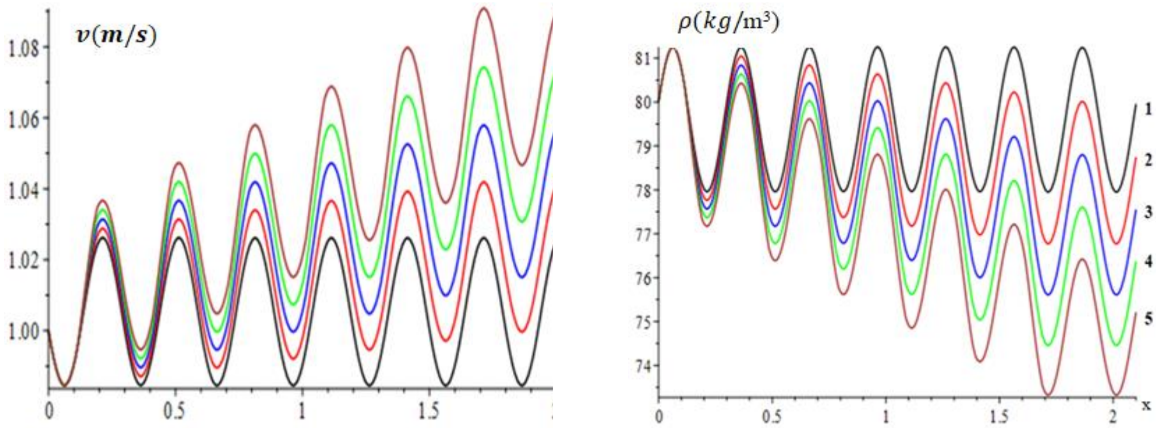
Fig. 3. Shows the graphs of the distribution along the conveyor axis of the flow velocity (a) and density ($б$) in the first section of the conveyor for m=7 at various values of the cotton bulk compression modulus K (kPa), as well as pressure p_c((Pa). Calculations were performed at the following parameter values: $v_0 = 1m/s$, $\rho_0 = 80kg/m^3$, $R = 0.3m, h = 0.3m, L = 2.1m$, $f = 0.3$



a) *b)*

Fig. 3. Graphs of changes in flow velocity (*a*) and density (*b*) in the first section of the conveyor at different pressures n_c(Pa along the conveyor axis at *K=12 kPa*: *1-*n_c*=0, 2-*n_c*=200 Pa, 3-*n_c*=400 Pa,4-n=600 Pa, 5-*n_1*=800 Pa*

These changes depend on the initial state of the cotton. For example, if the modulus of bulk density of cotton is K=12 kPa, then at a pressure of 0 (zero), the minimum value of the velocity varies in the range from 0,8 m/c to 1,03 m/s. The density varies from 81.2 kg/m³ to 78,2 kg/m³. If K=6 kPa, the velocity increases from 0,94 m/s to 1,05 m/s. The density decreases from 82 kg/m³ to 69.5 kg/m³.

At a pressure of 600 Pa, the speed increases from 0,8 m/s to 1,16 m/s. The density decreases from 81 kg/m³ to 74,5 kg/m³.

These patterns are repeated during the movement of cotton in other sections of the conveyor [11].

If the external pressure is 0 (zero), then the changes in velocity and density in the other section retain the law of the first section. If the pressure is 600 Pa, then at the end of the fourth section, i.e., at the output K=12 кPa and, P=600 Pa, the speed increases to 4,36 m/s. If K=12 кPa, the density decreases to 70 kg/m³.

If K=6 кPa, the velocity increases by 5,2 m/s. The density decreases to 55 kg/m³.

The regularity of the distribution of cotton flow velocity and density by section on the screw conveyor was determined. In this case, with a decrease in the volumetric compression modulus, an increase in the flow velocity and a decrease in the flow density across the section were observed.

It has been established that the amount of contamination decreases along the length of the screw conveyor. Based on this, the law of distribution of pollutant particles along the pipe under the influence of the air flow was studied. In this case, an increase in velocity along the pipe and a decrease in density were determined.

It was established that the study of the process of cleaning cotton from trash and dust in the sections of the cotton transporting device has a great influence on the optimization of the operating modes of the entire cleaner.

2. Study of the movement of fine trash, fibrous waste, and dusty air in the mixture transfer zone of the device.

By selecting a mixture of dust and fiber particles as a two-component medium, we analyze their velocities based on the models proposed in [12,13]. The following assumptions are accepted:

a) constant air flow velocity;

b) the weighted mixture of the medium is taken as "dust-fiber mass particles";

c) Mixture and air flows move uniformly and steadily in the pipe.

d) Dust fibrous mass particles and water vapor are obtained as a mixture.

We place the origin of coordinates in the initial section of the pipe and direct the Ox axis downwards. The motion of the mixture components is described by the Euler equation [14].

$$\rho_1 u \frac{du}{dx} = k_{01}(u_0 - u) + k_{11}(v - u) + \rho_1 g \quad (1)$$

$$\rho_2 v \frac{dv}{dx} = k_{02}\,(u_0 - v) - k_{11}(v - u) + \rho_2 g \quad (2)$$

Here $u_0 -$ air velocity, u(x) and v(x) velocities of fiber and dust particles, ρ_1 and ρ_2 - their densities, k_{01}, k_{02}- aerodynamic force between dust and fiber and air, $k_{12} -$ contact force between dust and fiber, respectively.

$$\rho_1 u = \rho_{10} u_{10},\,, \qquad \rho_2 u = \rho_{20} u_{20} \quad (3)$$

Here $\rho_{10}, \rho_{20}, v_{10}, u_{10} -$ are the densities and velocities of dust and fiber particles in the initial section of the pipe. Using these equalities, we write the equations ((1) and (2) in the following form.

$$\rho_{10} u_{10}, \frac{du}{dx} = k_{01}(u_0 - u) + k_{11}(v - u) + \rho_1 g \quad (4)$$

$$\rho_{20} u_{20} \frac{dv}{dx} = k_{02}\,(u_0 - v) - k_{11}(v - u) + \rho_2 g \quad (5)$$

When integrating equations (4) and (5) the densities ρ_1 and ρ_2 are determined by the equations of state for dust and fiber particle media. With high air velocity and small values of the distance, the densities can be assumed constant and equal to the initial ρ_{10} *and* ρ_{20} , then the solution of these equations will have a simple analytical form and they can be integrated under the following conditions.

$$u = u_{10}, v = v_{10} \quad (6)$$

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$v_{10}, u_{10} -$ velocities of dust and fiber particles in the initial section of the pipe.

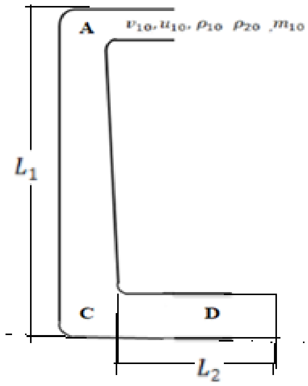

Fig. 4. Diagram of the mixture transfer zone of the device.

We present the system of equations (3) and (4) in the following form.

$$\frac{du}{dx} = -a_1 u + b_1 v + A_0 \qquad (7)$$

$$\frac{dv}{dx} = -a_2 v + b_2 u + B_0 \qquad (8)$$

Here

$a_1 = a_{01} + b_1, a_2 = a_{02} + b_{2,}\ \ a_{01} = k_{01}/\rho_{10}u_{10}, a_{02} = k_{02}/\rho_{20}u_{20}$

$b_1 = k_{11}/\rho_{10}u_{10}, b_2 = k_{11}/\rho_{20}u_{20}$

$$A_0 = \frac{u_0 k_{01}}{\rho_{10}u_{10}} + \frac{\rho_{10}g}{\rho_{10}u_{10}}, B_0 = \frac{u_0 k_{02}}{\rho_{20}u_{20}} + \frac{\rho_{20}g}{\rho_{20}u_{20}}$$

The general solution of the system of equations (6) and (7) is as follows.

$$u = A_1 exp(-\alpha_1 x) + A_2 exp(-\alpha_2 x) + C_0 \qquad (9)$$

$$v = \beta_1 A_1 exp(-\alpha_1 x) + \beta_2 A_2 exp(-\alpha_2 x) + D_0 \qquad (10)$$

Here

$$\alpha_{1,2} = \frac{1}{2}(a_1 + a_2 \pm \sqrt{(a_1 + a_2)^2 - 4(a_1 a_2 - b_1 b_2)})$$

$\beta_1 = (a_1 + \alpha_1)/b_1, \beta_2 = (a_1 + \alpha_2)/b_1$

$C_0 = \frac{a_2 A_0 + b_1 B_0}{(a_1 a_2 - b_1 b_2)}, D_0 = -A_0 + a_1 C_0$

3. Study of the movement of fine trash, fibrous waste, and dusty air in the mixture preparation zone of the installation.

Using equations (3) in the transition sections when integrating equations (7) and (8), it is possible to obtain boundary conditions in the transition sections [15].

When using these conditions, the weights of the media in the horizontal pipelines are not taken into account. In this case, the velocities in each zone are expressed by equations (9) and (10), for which the coefficients A_0 and B_0 have different forms.

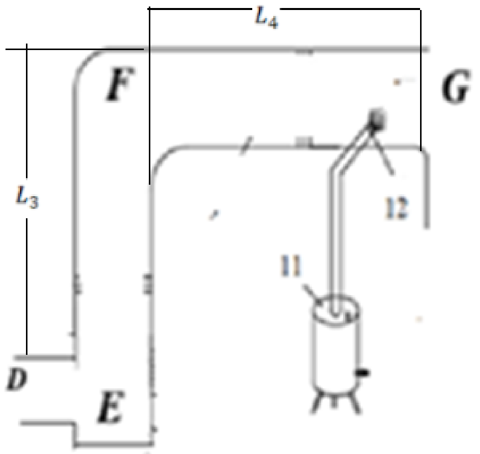

Fig. 5. Diagram of the mixture preparation zone of the device.

The calculations were performed at the following parameter values: $\rho_{10} = \frac{3kg}{m^3}$, $\rho_{20} = 5kg/m^3$, $u_{10} = 1\left(\frac{м}{с}\right), u_{20} = 1.5\left(\frac{м}{с}\right)$, $k_{01} = \frac{8Нс}{м^4}, k_{02} = \frac{12Нс}{м^4}, k_{11} = \frac{1Нс}{м^4}$, $L_1 = 1.6м, L_2 = 4м, L_3 = 1м, L_4 = 1.9м$,

а) *б)*

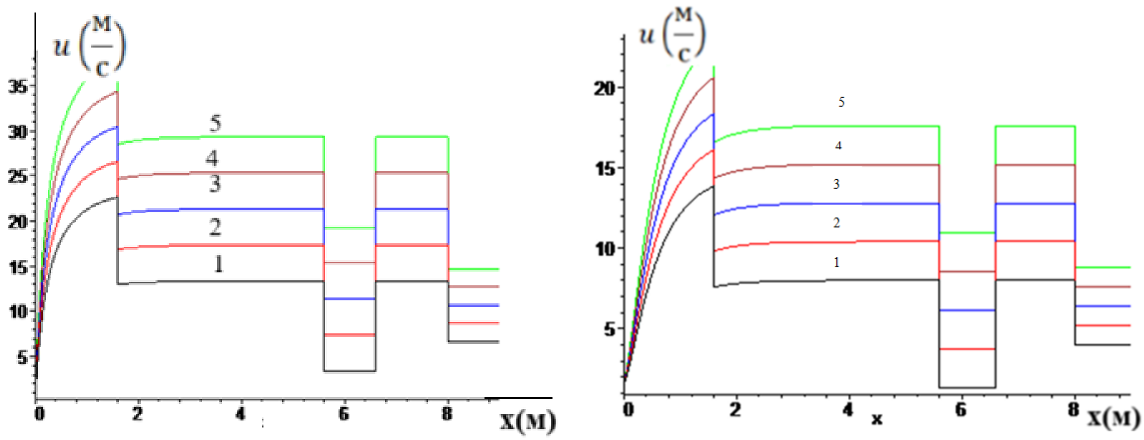

Fig. 6. Graphs of the distribution of air velocities $u\left(\frac{м}{с}\right)$ *and* $v\left(\frac{м}{с}\right)$ along the zones of the mixture preparation unit at different values of air velocity $u_0 \left(\frac{м}{с}\right)$

$1 - u_0 = 5,\ 2 - u_0 = 6.5,\ 3 - u_0 = 8,\ 4 - u_0 = 9.5,\ 5 - u_0 = 11,$

Conclusions. Based on the theoretical study of the cleaning of small trash and dust during the transportation of cotton, the following results were obtained:

1. A decrease in the amount of trash along the length of the screw conveyor was determined, an increase in its speed along the pipe and a decrease in its density were determined.

2. The fractional composition of fine trash and dust separated from cotton in the fine trash and dust separation zone of the device is 18,2-35,8% with a trash and dust particle size of up to 5 mkm; From 5 to 10 mkm 25,8- 42,7%; From 10 to 50 mkm 22,1- 33,5% and above 50 мкм 6,2- 24,8.

3. The mixture transfer zone of the device consists of 4 sections, and the air velocity takes the same value in sections 1-3.

In section 4, additional moisture was supplied to the mixture flow using a nozzle. In this case, the dust and fiber particles will have the greatest velocity in the first section.

4. In section 2, it was found that their velocities decrease relatively and it is necessary to increase the air velocity to transfer the flow to section 3. In particular, it was found that at the obtained values, the air velocity should not be less than $5\left(\frac{м}{с}\right)$.

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